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Description

Isolation Transformer

The present invention relates to an isolation transformer and in particular to an isolation transformer suitable for providing an isolation barrier in medical equipment.

Many types of medical equipment include sensors which are in contact with a patient. Although these sensors operate at low voltage and current levels that do not present a shock hazard to the patient that hazard can occur if an electrical short circuit occurs within the equipment or if other equipment connected to the patient develops a fault and the relatively high voltage and current levels from an external power supply line is supplied to the sensors contacting the patient.

For these reason regulatory authorities of many countries, such as for example the F.D.A. in the USA which requires compliance with IEC 60606-1, specify that medical equipment must be designed with an isolation barrier between circuits containing patient connections and circuits connected to power supply line voltages which can isolate against several kilovolts AC with a leakage current of only several microamperes when the supply line voltage is applied across the isolation barrier. Typically, suitable isolation barriers are formed using isolation transformers, usually mounted on a printed circuit board (PCB) containing the circuits to be isolated. Generally, one of the two circuits between which an isolation barrier is required is electrically connected to the primary transformer winding or windings and the other circuit to the secondary transformer winding or windings.

One known type of isolation transformer is a "bobbin-type" isolation transformer which comprises a hollow plastic former or bobbin about which wires are wound to form the primary and the secondary windings and through which a ferrite core piece passes. The wire primary and secondary windings may be wound concentrically, one on top of the other, or may be displaced

from one another along the core to increase the so called "creepage distance". The necessary isolation may be achieved by sheathing the wire of the two sets of windings in a suitable insulating material. This provides a transformer which is relatively inexpensive to produce and one in which faulty windings can be readily replaced.

However, the isolation in this type of transformer is largely an issue of the separation and insulation between wires and the windings which mitigates against minimising the size of the transformer for mounting on the PCB. Size of the transformer can become a major issue since the medical device typically needs to accommodate several PCBs, one or some of which may have mounted thereon isolation transformers, in a small a volume as possible. Moreover, complicated tapping arrangements for the windings are difficult to achieve in wire wound transformers and often lead to a high failure rate and a consequent increased unit cost.

Low-profile planar transformers are also well known as isolation barriers. In such transformers the primary and secondary windings are each made as electrically conducting traces, usually on an insulating planar surface such as a surface of a PCB, for example a multi-layer PCB, and arranged so that successive traces are separated by an insulating PCB layer to provide at least part of the necessary isolation. The layer or layers that constitute each of the windings are then usually magnetically coupled by means of an inductive core member. Forming the windings on a PCB also provides an increased ease of tapping selected conducting traces to provide a selectable transformer output voltage as compared to tapping selected windings of a wire wound transformer. This also allows complex tapping arrangements to be constructed relatively simply and consistently.

However the bonding of the PCB layers is usually done by gluing which also contributes to the isolation but can lead to uncontrolled variations in the dielectric properties of

the inter-trace insulation, for example through the uncontrolled formation of air bubbles within the glue as it is applied. This is of particular concern for the insulation between the primary and the secondary windings as it may adversely effect the isolation provided by the transformer This leads to the necessity for increased quality control and hence higher unit costs.

It is an aim of the present invention to provide an isolation transformer of relatively small size in which the isolation characteristics can be readily controllable.

Accordingly the present invention provides an isolation transformer as described in and characterised by the present Claim 1. By providing one winding as a planar conductive trace on an insulating substrate a reduction in size and an ease of tapping as compared with an all wire transformer is achieved and by providing an insulated wire winding substantially all of the electrical isolation can be achieved by a suitable tailoring of that insulation in a manner well known in the art. Moreover, the isolation can be tested before the wire is turned to provide the transformer winding, thereby reducing the possibility of the completed transformer being rejected during quality control. Thus, the "hybrid" transformer of the present invention provides an isolation transformer having advantages associated with each of the planar and the wire wound transformer whilst mitigating their disadvantages.

Usefully the wire may be turned about a hollow bobbin similar to the known bobbin type transformer arrangement or other former, such as a leg of an E-core ferrite element, to provide for ease of collocation of the primary and secondary windings into the final transformer. The bobbin (or former) and the planar windings may be releasably collocated which has the advantage that since the isolation is provided by the insulated wire winding poor isolation caused by faulty insulation in an assembled transformer can be easily remedied

without replacing the entire transformer. This is particularly advantageous in circumstances where the planar conductive trace winding is formed integral with a PCB, for example a multi-layer PCB, which also contains the circuits to be isolated from one another by the transformer.

Embodiments of the present invention will now be described with reference to drawings of the accompanying Figures of which:

Fig. 1 shows an embodiment of the isolation transformer according to the present invention.

Fig. 2 shows an example of a planar conductive trace used as a component of a winding of the transformer of Fig. 1

Fig. 3 shows a further embodiment of the isolation transformer according to the present invention.

Referring now to Fig. 1 an isolation transformer 1 is shown comprising a wire winding 2; a planar winding 3 and a magnetic core element comprising a conventional co-operating E-core 4 and I-core 5 arrangement. Spring clips 6,7 are provided to hold the cores 4,5 together in the assembled transformer.

The wire winding 2 comprises a plurality of turns spirally wound about a central leg 8 of the E-core 4. The wire winding 2 is formed from a wire 9 within an insulating sheath 10 of sufficient thickness to provide an isolation between the wire 9 and the leg 8 and between the winding 2 and the planar winding 3 to withstand an applied voltage of 1500 V (RMS) and a 5000V defibrillation pulse which may be applied to a patient in cardiac arrest in an attempt to re-start or stabilise the heart output.

The planar winding 3 comprises a plurality 11a, 11b, 11c of printed circuit boards bonded to form a stacked arrangement locatable about the central leg 8 of the E-core 4. Thus the

central leg 8 magnetically couples the two windings 2, 3 in the assembled transformer 1. Each circuit board 11a, 11b, 11c is, on at least one of its planar faces, provided with a conducting trace (not shown). These traces together comprise the conventionally formed planar transformer winding 3. Since the isolation is provided by the insulation 10 about the wire winding 2 then the isolation demand between any of the traces, whether on the same or another layer, is no higher than it would be between any trace on a conventional printed circuit board.

Considering now Fig. 2 an exemplary printed circuit board (here for example 11a) of the planar winding 3 is shown in more detail. A planar conductive trace comprising two tracks 12a, 12b has been formed on one surface 13 of the printed circuit board 11a in a conventional manner. These tracks 12a,12b are arranged concentrically with a hole 14 through the board 11a through which the central leg 8 of the E-core 4 (Fig. 1) passes. Through-holes 15a, 15b, 15c are also provided in the board 11a and are conductively plated to allow the electrical connection of traces on the other boards 11b, 11c which comprise the planar winding 3. Additional plated through-holes 16a, 16b, 16c, 16d are provided to allow electrical connections to be established between the planar winding 3 and external of the transformer 1 (for example to permit the connection of different combinations of tracks to different circuits).

A further embodiment of an isolation transformer 17 of the present invention is shown in Fig. 3 in which the planar winding 18 of the transformer 17 is formed as an integral part of a multi-layer printed circuit board 19 (only part shown in Fig. 3) on which is also provided circuits 20, 21 to be isolated from one another by the transformer 17. The transformer 17 further comprises a first E-core 22 configured with a central leg 23 which passes through a plastic bobbin 24 about which is wound an insulated wire winding 25. The winding 25 is insulated sufficiently to provide the

substantially all of the desired isolation between the two windings 25,18 of the transformer 17. Contact legs 26 project from the base of the bobbin 24 and are connected to opposite ends of the wire winding 25 to provide for electrical connection of the winding 25 external of the transformer 17. A second E-core 27 is provided to complete a magnetic flux path coupling the windings 18,25.

The circuit board 19 is here shown to comprise 5 layers 28-32. The first layer 28 has an upper surface 33 on which the two circuits 20,21 to be isolated are realised. Three through holes 34,35,36 are provided and are dimensioned to permit passage through the board 19 of the legs of the E-cores 22,27. Two plated recesses 37, 38 are provided in the upper surface 33 to receive the contact legs 26 and are electrically connected to the circuit 21, which is typically connected to receive mains power. Three plated holes 39 pass from the upper surface 33 to the planar winding 18 to provide electrical contact to different numbers of turns of the planar winding 18 and are electrically connected to the other circuit 20, which is typically connected to patient sensors (not shown). All of these electrical connections 34-39 can be readily arranged on the upper surface 33 of the multi-layer printed circuit board 19 to provide the correct creepage distances to meet the appropriate national or international regulatory requirements.

As illustrated in Fig.3 the planar winding 18 is realised in the layers 29-31, each have on their upper surfaces (relative to the upper surface 27) a conductive trace, for example similar to the trace 12a, 12b shown in Fig. 2, to form the planar conductive winding 18 in the region shown by the broken lines. With this arrangement a degree of isolation between the wire winding 25 and the planar winding 18 is also provided by the thickness of insulating material in the layer 28.

Claims

1. An isolation transformer (1;17) comprising a magnetically coupled primary and secondary winding arrangement (2,3;18,25); and insulation means disposed to provide a desired level of electrical isolation between the primary and the secondary windings characterised in that one of either the primary or the secondary winding (3;18) is formed of at least one insulating substrate (11a,b,c;29-32) having on a surface thereof a planar conductive trace (12a,12b) and the other (2;25) is formed of a plurality of turns of an insulated wire conductor (9), the insulation (10) of which is adapted to provide the desired level of isolation.

2. An isolation transformer (17) as claimed in Claim 1 characterised in that the wire winding (25) is provided spiralled about an outer surface of a hollow bobbin (24); the planar trace winding (18) is coaxially arranged about a hole (35) through the at least one insulating substrate(29-32); and in that there is further provided a magnetic core element (22,27) positionable through the hole (35) and the hollow bobbin (24) to magnetically couple the windings (18,25).

3. An isolation transformer (1;17) as claimed in Claim 1 or Claim 2 characterised in that the primary and the secondary windings (2,3;25,18) are releasably collocatable.

4. An isolation transformer (1;17) as claimed in any preceding claim characterised in that the planar conductive trace winding (3;18) is the secondary winding.

5. A printed circuit board assembly comprising a multi-layer printed circuit board (19) having thereon one or more discreet electric components arranged in two electrically separate circuits (20,21) and an isolation transformer (17) having primary and secondary windings (25,18) each winding connecting to a respective one of the two circuits to

transfer power therebetween characterised in that the transformer comprises a transformer (1;17) as claimed in any previous claim wherein the winding (18) formed of at least one insulating substrate is provided by the layers (29-32) of the multi-layer printed circuit board (19).

6. A printed circuit board assembly as claimed in Claim 5 characterised in that a one (20) of the two circuits (20,21) is adapted for connection to patient sensors and is connected to the winding (18) formed of at least one insulating substrate.

Abstract

Isolation Transformer

An isolation transformer (1) comprises a magnetically coupled primary and secondary winding arrangement (2,3). One winding is formed of at least one insulating substrate (11a,b,c;) having on a surface thereof a planar conductive trace and the other (2) is formed of a plurality of turns of an insulated wire conductor (9), the insulation (10) of which is adapted to provide the level of isolation between the primary and the secondary windings necessary for use in medical equipment. The winding arrangement (2;3) is releasable collocated on a central leg (8) of an E-core (5) which, together with an I-core (5) against which it is releasably held by spring clips (6;7), provides the magnetic coupling.

<u>Fig. 1</u>

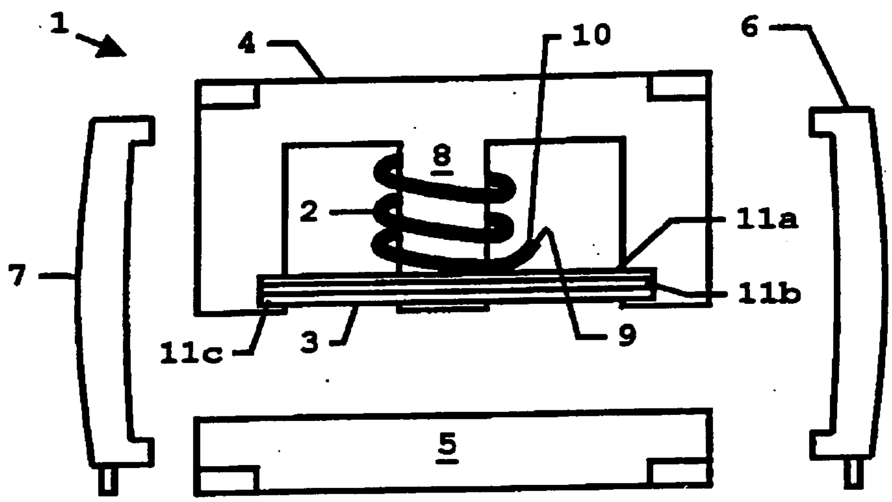
1
4
10
6
8
2
11a
7
11b
11c
3
9
5

FIG. 1

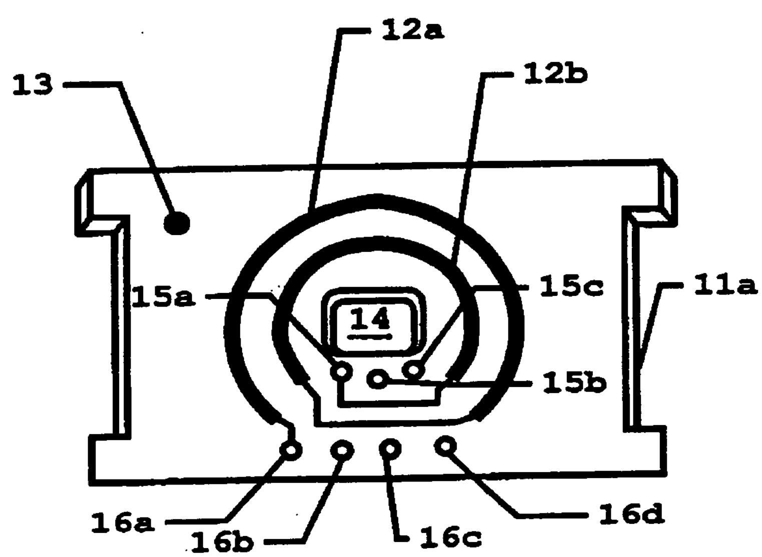
12a
13
12b
15a
14
15c
11a
15b
16a
16b
16c
16d

FIG.2

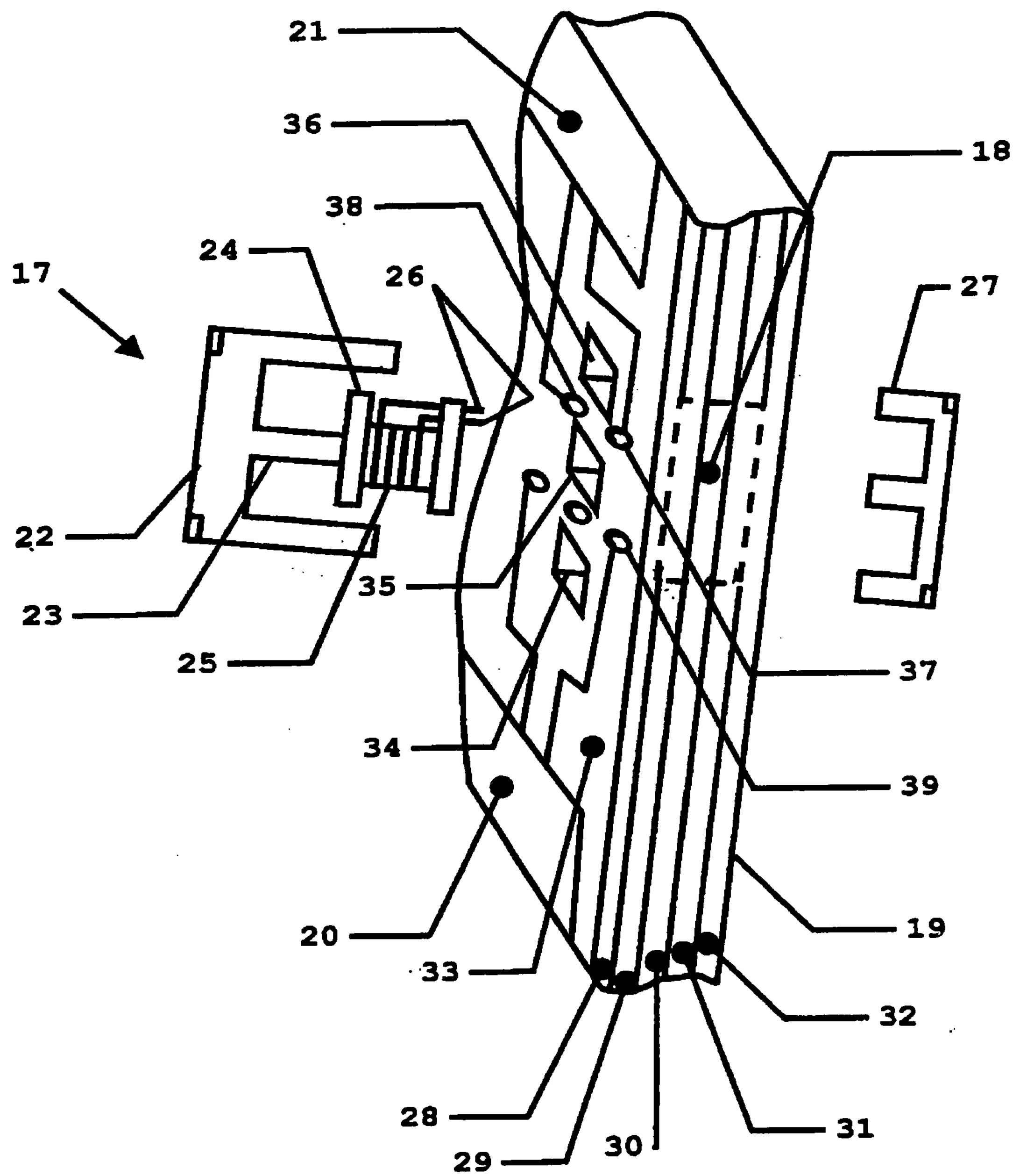

FIG. 3